

L [R.] 51096/P

REPORT

ON

SUPPLYING GLASGOW

WITH

WATER.

BY R. THOM, C. E.

GLASGOW:

FROM THE STEAM PRESS OF EDWARD KHULL,
PRINTER TO THE UNIVERSITY, DUNLOP STREET.

MDCCCXXXVII.

216 H 56



NOTICE

A PRIVATE letter written by me the other day, in which notice was taken of a letter from the Mayor of Angers, having found its way into the newspapers, has induced me to give here a copy of that letter.

My letter to Mr. Hosier was written in great haste, and from its contents, every one who knows me will see that I never intended it for the public; but those who know me not, may look upon it as a puff—the common practice of the times: and hence my reason for now printing the letter itself. It is only one of many similar applications which I am frequently receiving from all parts of the world.

I have also printed a Report for supplying Edinburgh with water, for the purpose of showing that the principles I now recommend for adoption in the Glasgow scheme, are not new *to me*.

The Glasgow Report has been written in much haste, and sent to the printer sheet by sheet as scrolled. It cannot therefore be expected to be so clear and correct, as it is my practice to make such Reports; but the substance is correct; and had been long and fully considered, *before* I put pen to paper on the subject. Time did not allow me to give the

calculations of the probable returns upon the sum estimated; but it is ample, and will be immediately added, with many other useful remarks, for there is not an hour to lose.*

After the most careful inspection, and most deliberate consideration, as to the merits of the question in all its bearings, both Mr. Walker and myself were decidedly of opinion, that it would be for the interest of the Shareholders, as well as the public generally, to bring the matter before Parliament this Session, provided it should be found practicable. With this view we carefully examined the grounds, as well as the plans lodged; and though (for reasons now well known to the Directors) these plans were not finished in that neat and handsome manner, which surveyors of taste are very properly fond of exhibiting; yet we have found them correct in all essentials; and the levels on the grounds I have now ascertained by personal checks to be very accurate.

There appears nothing, therefore, in the engineering department to prevent the Company going forward; and as to the additional subscriptions necessary, many gentlemen, I know, only waited to learn *the real state in which matters stood*. There was at one time cause for this prudent delay—that cause is now, in my opinion, completely removed; and therefore, none who have confidence in my opinion, need longer hesitate to come forward. If it were wished, and thought prudent, I am ready to take shares myself to a very large extent, as stated in the body of the Report. Let therefore the friends of the measure, which I believe to be more than nine-tenths of the community, now come boldly forward; if they do so, and maintain that unity of counsel and action now fairly established, they may rest assured of ultimate and complete success.

It appears to me, for reasons which it might not be prudent to state here, to be of the utmost importance that you should go before Parliament this Session. If this is not

* This document is now inserted at the end of the Report, p. 11.

done, the public will, I fear, have cause to regret the delay when too late. At all events, let the subscriptions be filled up to the extent necessary for lodging your petition in time, which must be before Tuesday evening next; that is, it must at latest leave Glasgow by the mail on Wednesday morning. You are aware that Mr. Walker, when here, strongly advised this step to be taken at all events. I fully agreed with him; and the expense for that purpose is already incurred. After the petition is lodged, you may take two, or probably three months, to consider the propriety of going farther this season, should such length of time for consideration appear necessary and proper.

I need not remind the directors, but there may be others interested whom it is proper to remind, that the last resource of unreasonable and baffled opponents, is delay—plausible and *pretended* prudential delay! When all other arts and arguments fail with a member or party in Parliament, this is uniformly the last shift. When a disappointed member can do nothing else, he tries to exhaust the patience of the House by moving an adjournment, night after night.

Think not from this that I advise rash measures; should good cause for delay afterwards appear, I shall be the first to urge its adoption.

R. T.



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REPORT, &c.

To the Directors of the New Glasgow Water Company, the Report of ROBERT THOM, C. E.

AGREEABLY to the instructions of the Directors, I have caused an accurate check survey to be made of the whole Calder scheme, and have also again inspected the whole line of aqueduct, and site of the reservoir, accompanied by Mr. James Walker of London, who agrees with me in every thing regarding the same, giving it of course a decided preference over that of the Avon, which we also inspected with great care. This preference is due to the Calder scheme in many respects; its vicinity to Glasgow; the absence of all public works below the reservoir; its simplicity, and consequent economy; but above all, the unlimited quantity, and superior quality of its waters, when allowed ample time to subside, and made to pass through improved filters, precisely similar to what they must pass through if taken for the supply of the city of Glasgow. The great advantage possessed by the Calder water over that of the Avon and most others, is the entire absence of that dark tinge which is produced by the decomposition of moss, or other vegetable matter, and generally known by the name of moss water. The soil from which the waters of the Calder drain, is chiefly composed of argil or clay, on which account it generally assumes a reddish colour during floods; but when ample time is given to such waters in a deep lake or reservoir, this argil or clay falls to the bottom, and carries along with it any vege-

table or other matter, which might otherwise have remained in and injured the water.

In the very driest seasons, there may be about three months in the year, that the waters flowing down the Calder will not be sufficient for the supply of Glasgow; but even during these three months, it will be upon an average equal to fully one half of that supply. If, therefore, a reservoir be made large enough to hold six weeks' supply for the city of Glasgow, we may safely calculate on a full, regular, and uniform supply, in the very driest year. But the reservoir now proposed will contain a quantity capable of supplying Glasgow for more than five months, or more than three times the quantity now required. The present scheme, therefore, if carried into full effect, would be able to yield an abundant supply to the city of Glasgow, though its present population should be more than doubled. And by increasing the reservoir proportionally, that supply might be *again* more than doubled; for, if the *whole* waters flowing down the Calder were to be *preserved*, it would yield more than ten times the supply now required by the city of Glasgow. I have ascertained also, that the water from the South Calder, and even from the Clyde itself, might be easily carried into this reservoir. These last mentioned waters, particularly that from the South Calder, might be easily collected in reservoirs, and carried by a small aqueduct into the Monkland Canal, thus giving that, and consequently the Forth and Clyde Canal, the most abundant supply of water at a moderate expense.

The embankment for forming the proposed reservoir is to be thrown across the course of the Calder water at Braehead Mill near Aitkenhead, to such height as will dam back the waters, to the waterfall below Rosehall House. Besides this main embankment at Braehead Mill, it is proposed to make another near the junction of the water of Luggie with the Calder. This will divide the reservoir into two distinct compartments, so that the water from the lower compart-

ment may be drawn off, while the higher is filling; and the lower be again filled from the higher when its waters shall be found settled and clear, so that the water drawn off for the supply of Glasgow will always be pure lake water, however different at different times the colour or complexion of the waters passing down the river may be.

A new water course will be carried round one side of the lower compartment of the reservoir, to carry past the surplus water, when the upper compartment is full. It is also in contemplation to form a small water course, or aqueduct, round the reservoir, for the purpose of carrying past any water of a bad quality, such as that in which flax may be steeped, so that no water containing any thing unpleasant to the taste, or injurious to health, will ever be allowed to enter the reservoir.

From a tunnel in the embarkment at Braehead Mill, the water will be carried to Glasgow, by a close aqueduct of brick or stone (several feet under ground), and surrounded by vermin puddle. At the end of this aqueduct, or stone pipe, and just before entering the distributing basin, the water will pass through an improved filter, which will render the entrance of any extraneous, or impure matter into the pipes altogether impossible. This basin, situated near the House of Refuge, will be high enough to supply nearly the whole city, except the Rottenrow, Blythwood hill, and a few other very high situations; and for supplying these, the water is proposed to be raised by a small steam engine into a high basin near Knox's monument, from which it will again descend, by gravity, in small pipes laid for that purpose, to the very few situations too high for the lower basin. It is also in contemplation to make a basin (for supplying steam engines, and other purposes not requiring filtered water) into which the water for such purposes will flow without passing through the filters. In this way steam engines and other public works, may be supplied at a very low rate, while even the unfiltered water thus given them will be much purer than that supplied by the present water works.

Of the quantity and quality of the water thus proposed for supplying Glasgow, there can be no rational doubts. I have at all the various states of the river lifted water from the Calder; and by putting it through a process precisely similar to that which it must undergo if brought in to supply Glasgow, it has invariably proved to be of the very best quality for all domestic purposes. I have samples of it now beside me, which any Gentleman may see, on making application for that purpose.

I formerly estimated the expense of this scheme at one hundred and sixty thousand pounds (L.160,000) on the data of giving water of a much better quality, and to a much greater extent, than is now furnished by both water companies. I still adhere to that opinion, after the most careful and laborious investigation of all matters and things connected with it. The sum allowed for executing the works, is, I know, beyond what they can be executed for. In regard to the land and houses interfered with, I have allowed more than a half beyond their real value, or more than a disinterested jury would award. I am aware that much opposition is threatened; but if the new company continue firm and united, I am of opinion that the opposition will not be so great as some would endeavour to make us believe. With what grace or prospect of success could a scheme be opposed which it will be easy to demonstrate can injure no one save the present water companies, while it is supported by the whole population of Glasgow, demanding no more than the natural right which the Great Creator of the universe has bestowed upon all, even the lowest of animals, and without which they cannot even exist. Will the profit or loss, of a few individuals, (the object once fairly developed, and cleared of the cobwebs of interest and artifice), be allowed by the Legislature to deprive the whole community of Glasgow of their natural and indispensable right to a full supply of the first necessary of life—pure and wholesome water at the lowest possible rate? Let

it not be thought, because I thus plead the cause of the community of Glasgow, that I am hostile to the present Water Companies—very far from it. I do not even join in the hue and cry invidiously raised against them by some as monopolists, quite regardless of every interest but their own. I believe they have only acted as most other men would have acted under similar circumstances. They have sunk a good deal of money on what proves to be an unprofitable speculation, and therefore try to better themselves in the best way they can. But though we may not have a right to make invidious remarks upon their conduct, it does not surely follow that the citizens of Glasgow generally must either make up their loss, or be deprived of their unalienable right to the first necessary of life—an abundant supply of pure and wholesome water.

The answer given very lately by a clear-headed practical statesman, the Duke of Wellington, to a most pathetic address and application for public support to the sisters of the late gallant Colonel Hamilton, is exactly in point, and quite decisive of all such claims: “If (said his Grace) people will, from greed of more than common interest, risk their capital, they can have no right to appeal to the public to make up their loss when the speculation proves a bad one.”

If the carrying of this scheme into effect should, therefore, be the innocent cause of individual loss, that loss must be made up in some other way than by a general tax on the community. Who would even dare to propose, *openly*, that the whole population of Glasgow, and particularly such an immense number of poor and industrious families, should be permanently taxed to make up the private loss of speculative individuals? And yet, disguise it as we may, this would be the direct and palpable effect of any compromise between the new and the old Water Companies, which could in any way, directly or indirectly, have the effect of compensating the old Companies for any part of their loss; and if it is not meant that they should be

compensated, what is the use or meaning of any such compromise? Why propose to make what is now simple and plain to every comprehension, complicated and obscure? And, what is infinitely worse, would, for many years to come at least, deprive the community of Glasgow of what is now clearly within their reach—a most abundant supply of pure and wholesome Water for half the money they now pay for a scanty supply of very inferior Water. It is easy for ingenious or artful men to form very plausible schemes or arrangements, in order to cover the real object in view; but they should remember that “interest is eagle-eyed;” and how would such schemers or plotters look, when the real object of all their artifices and intrigues would be exposed to the full gaze of a duped and indignant public? It is not in the nature of things to make any arrangement which should mix up the stock of the old Companies with that of the new, that would not inevitably have the effect of making the water dearer to the inhabitants of Glasgow. Nor would this be the worst of it; its effect, to a certainty, would be most injurious to the *quality* of the water. It is well known how difficult it is, even with the most intelligent of men, to make them at once abandon or throw away what has cost them much care, thought and money. How many of such men have injured the finest designs of modern skill by cramping the genius of the inventor, and obliging him to raise the superstructure upon a foundation of barbarous taste. To come home at once—how many modern mansions have we lately seen rendered both inconvenient and unsightly, by retaining the old buildings as a part of the new? But even these instances of mistaken economy are nothing in their effects, compared to what would be the result of mixing up the stock, and ill-assorted, injudicious, and disproportioned materials, belonging to the old Companies, with the unity and simplicity of the plan or system proposed to be adopted by the new Company. To do this would certainly be putting new wine into old bottles in the most emphatic meaning of the parable.

It is now but too well known that no community can have a constant and uniform supply of good water, when that supply is taken *directly* from any stream or river, without the aid of *large* and *deep* reservoirs, into which the waters of that stream or river shall be collected, and allowed ample time and space for depositing their impurities, before they are allowed to enter the pipes for supplying such community. In a late Report to the Directors, I have demonstrated the impracticability of remedying this defect (the want of a reservoir) by filtration; on account of the enormous expense of rendering water in a very thick or turbid state pure by any such process.* When water has had ample time to *share*, or deposit the extraneous matter contained in it, till it has become *limpid* or *clear*, filtration may then be applied with good effect to complete its purity. But filters are so soon choked when the water is in a very muddy or turbid state, and pass so little pure water at such times, that their expense on a scale so large as to be able then to pass enough for a large and populous city, renders their application all but impracticable.

But the state of the pipes as now laid, is of itself a sufficient cause for not mixing up the stocks of the old with that of the new Company. To understand this it will be enough to quote the following from the two Reports above referred to. "To give a supply of water uniformly good to a city, it is therefore necessary, not only that the water should be constantly and uniformly pure before it enters the pipes, but that the pipes themselves should be so constructed and laid as to give the utmost facility for the removal of all impurities they may contain, the moment they are known to be there. Now it is well known that many of the pipes were first laid to receive the water from the west end of the city, and afterwards it was made to enter them from the east end. Other ranges of the pipes are laid, so that the water enters at both ends occasionally; and some of them receive the water at neither end, but at some intermediate place; so that

* See also the Report for supplying Edinburgh with water.

instead of everyrange of the pipes being laid, that the water may enter at the higher and wider end, and be run off by a large scouring valve at the lower end, carrying with it all sediment or dirty water, they are laid here and there, in all positions; and the water, by sometimes flowing up the range, and sometimes down or across it, in every direction, keeps the water in a constant jumble, thereby keeping afloat any mud or sediment contained in the pipes, and of course generally given out along with the supply of water. Besides, most of the pipes being laid too near the surface of the streets, the water, during the hot summer weather, becomes very much heated, particularly in the hollows of the streets, or bends of the pipes, where it is apt to stagnate, and become nearly putrid. This is one, among several others, of the causes why the water is generally so bad in hot summer weather; and, like most of the other causes, could only be cured by the pipes being wholly lifted and re-laid. But many of them are unfit for this, partly from their being too small and ill-proportioned, and partly, that many of them would give way in the process of being put through the fire in cleaning. These, as above noticed, are some of the causes why the stock of the old companies ought not to be amalgamated with that of the new company.

But if it be agreed to carry the new scheme fully into effect, and it be allowed to stand fairly on its own bottom; then, on such terms, I myself am ready to be one of twenty to come forward and subscribe all the additional money wanted by the New Company; and if the management shall be to my mind, to advance shilling for shilling with the other nineteen, who may be able and willing to come forward in the same manner; and along with them, and the other subscribers, I shall run all risks of obtaining the Act of Parliament, as well as every other risk; and with them continue to persevere in the good cause, until the grand work shall be finally accomplished!

R. THOM, C. E.

Estimate of the Probable Return upon the Capital of the New Glasgow Water Company.

THE annual revenue of the present Water Companies is generally understood to be L.25,000 ; but take it at L.23,000. From the very superior quality of the water of the new Company, and the low price they can afford it at, there can be no doubt of a greatly increased demand almost immediately—Say to the extent of L.32,000, (at the same rate,) in the course of a very few years ; and supposing them to charge only one half the present rates, this would still yield a return of L.16,000

This, no doubt, supposes the new Company to supply the whole ; and it is needless to mince the matter ; I do not believe that the old Companies could stand in competition with the new Company.

Take, therefore, the annual revenue of the new Company at	L.16,000
Five per cent. on the estimated cost of the works, is	L.8000
But supposing they should cost L.180,000, instead of L.160,000,	
in the event of an extraordinary combination between, and opposition from, both the old Companies and the land-owners ;	
this would be interest on other L.20,000, (say L.1000 more,) or upon the whole	L.9000
Annual expense of a fifteen-horse engine, say	300
Four Watermen, with occasional assistants	200
Office, Manager, and Clerks, L.450 ; furnishings of all sorts,	
L.350	800
	— 10,300
	<hr/> L.5,700

Thus leaving a surplus of L.5,700, after paying five per cent. on capital, and all other charges.

Thus, therefore, taking the very worst view of the matter, the shareholders would divide above eight per cent. upon their capital, while the inhabitants of Glasgow would have the most abundant supply of the purest water, at one-half the price they pay for it at present.

R. T.

EXTRACT

REPORT OF ROBERT THOM,

CIVIL ENGINEER, ROTHESAY,

UPON THE

Plentiful and Economical Supply of the City of Edinburgh with Pure Water, and the Construction of Reservoirs for remedying the Deficiencies, and increasing the Water Power on the Water of Leith.

Rothesay, 16th April, 1829.

AT the desire of MICHAEL LINNING, Esq. of Colzium, the Reporter inspected the grounds and streams near the sources of the Water of Leith, on the 4th and 5th days of August, 1826, for the purpose of ascertaining how far they could afford a supply of pure water for the City of Edinburgh, in connexion with a more regular and uniform supply for the various mills on the banks of that river.

It may be premised that the summer of 1826 was uncommonly dry; and as Mr. Linning and others stated to the Reporter on the grounds, that no rain had fallen there for a considerable time previously, the streams at the time of this inspection may be considered at their minimum.

Measuring the Streams.

Instead of measuring *separately*, the almost innumerable springs, which at this time formed, exclusively, the streams of Wester and Baads Burns, the joint produce of these springs was measured, after being collected into these streams near their conjunction between Easter Cairns and Harper-

Rig. At this time, these waters were, as they frequently must be, entirely free of moss, and quite fit for all domestic purposes.

The quantity of water at this time flowing in the Wester Burn was one hundred and two (102) cubic feet per minute; in Baads Burn sixty-three (63) cubic feet: together, one hundred and sixty-five (165) cubic feet per minute, or two hundred and thirty-seven thousand six hundred (237,600) cubic feet in twenty-four hours.

Now, allowing two cubic feet a-day for each individual, this will supply a population of one hundred and eighteen thousand eight hundred (118,800) souls, which is more than the City of Edinburgh is likely to require, in addition to its present supply. But besides these, there were various other available springs and streams, producing together one hundred and fourteen (114) cubic feet per minute; which, with the former, makes above four hundred thousand (400,000) cubic feet of pure water in twenty-four hours; being a full supply, in the very driest season, for two hundred thousand (200,000) inhabitants.

Quantity of
Water to each
individual.

It is true, indeed, that *during floods*, the waters of all streams become more or less turbid or impure; and during *some* floods, particularly towards the end of summer and in autumn, the Water of Leith must be mixed, to a considerable extent, with decomposed vegetable matter, giving the stream that tinge which is commonly called moss-water, which matter can only be separated from the water by chemical agency. But during the greater part of the year, the water will be entirely free from such tinge, and in quantity much greater than can be wanted for the City of Edinburgh; it is therefore only necessary, at the proper times, to collect and detain as much of this good *surplus* water as shall be sufficient for the supply of the City, on occasions when the water in the stream itself is turbid or impure.

Quality of all
River Water
variable.

For this purpose, a Reservoir should be formed upon grounds free of moss—or, if there is a little moss, it should

How to form a
Reservoir for
Pure Water.

be removed—or, during dry weather, trenched and burnt, and the ashes carefully spread over the bottom of the Reservoir, which, like every description of charcoal, will improve the water in contact with it.

Connected with this Reservoir, an Aqueduct and by-lead should be formed; the first to carry the water, when pure, *into* this Reservoir; and the second to carry it, when impure, *past it*, into another for the use of the Mills. Self-regulating sluices may be placed upon these, so as to leave very little to the discretion of the watermen.

Conveyance of
Water by a
Stone Aqueduct.

With regard to the conveyance of this water to the City of Edinburgh, the Reporter is of opinion that it may be carried, in a stone aqueduct, from a Reservoir formed a little above East Cairns to a place in the vicinity of Craiglockhart, where it will fall into a regulating Cistern. This place is 13,067 feet from, and 227 feet above, the Hay-market. From this small Reservoir, the water will be carried into the City by cast-iron pipes in the usual way.

An Aqueduct of this kind was constructed some time since for the Greenock Water-works, which answers the purpose completely. It is formed of freestone, nicely joined and cemented, and surrounded with vermin-puddle;* so that if by any chance a joint should fail, the puddle will still keep the Aqueduct perfectly water-tight. This Aqueduct is, in the opinion of the Reporter, preferable, in every respect, to a cast-iron pipe, except in cases where the pressure must of necessity be great; but no such necessity exists here, or generally any where, so long as the regulating cistern can be placed on ground sufficiently elevated to raise the water in the metal-pipes to the highest point of delivery.

Such Aqueduct, made in the most substantial and lasting manner, will only cost about one-fourth the price of a cast-iron pipe of equal capacity; and it is well known, that water

* A composition of clay and small stones, such as to render it at once impervious to water, and to moles, water-rats, and other vermin.

flowing over stone is rather improved, which is not the case in flowing over iron.

With regard to the necessary Reservoirs, one or more will be wanted for the use of the Mills, and one or more for the pure water for the supply of the City. The first should be large enough to contain *all* the surplus water of the wet season, so that the supply for the Mills would be regular and uniform throughout the year. This would greatly enhance the value of these Mills; indeed, wherever such uniform supply is not obtained, the value of such property must be very uncertain.

The Reporter is still of opinion, that the best site for a main Reservoir for the Mills is on the low grounds on the banks of the Water of Leith, between Harper-Rig and East Cairns, as reported by him to Mr. Linning several years ago, and since frequently referred to by others, though without acknowledgment. He is also of opinion, that the estimate then made by him was correct to the extent it went; but being then limited by his instructions, the Reporter would now recommend, as he did formerly, that this main Reservoir should be made as capacious as the situation will admit; and also that one or more auxiliary Reservoirs be formed farther down the River, to retain the surplus waters *from all the drainage below that of the main Reservoir*. Without such auxiliary Reservoirs, there would still be a great waste of water; but by *their* detaining, during every flood, the surplus waters from the lower drainage, and again letting it off as soon after every flood as necessary, the main Reservoir would be enabled to collect a much greater quantity of water during the wet, for the supply of the dry, season.

The Reporter is of opinion, that the cost of forming such main and auxiliary reservoirs will be about Six thousand one hundred (L.6,100) pounds. The value of the land thereby flooded, say one hundred and twenty (120) acres, at twenty-five (25s.) shillings, thirty years' purchase—four thousand five hundred (L.4,500) pounds. House and lands for the

Reservoirs.

Main and Auxiliary Reservoirs for the Mills.

Cost of Main and Auxiliary Reservoirs for the Mills.

waterman, four hundred (L.400) pounds; incidents, ten per cent. eleven hundred (L.1,100) pounds—together, Twelve thousand one hundred (L.12,100) pounds.

Sites for, and
Cost of Reser-
voirs for Pure
Water.

With regard to reservoirs for the pure water, two sites may be found above Easter Cairns, and one or more nearer Edinburgh; and the reporter inclines to think that more than one should be formed, in order that, not only the pure water from Wester and Baads Burns, but also that from several other springs and streams which fall into the Water of Leith afterwards, should be made available for this supply. The reporter is of opinion, that reservoirs sufficiently capacious for this purpose may be formed, including the necessary aqueducts and sluices for carrying the water into or past them, as its quality may be pure or otherwise, and also the price of the land, for a sum not exceeding four thousand (L4,000) pounds.

Collecting the
Springs, &c.

It will be proper to remove the moss, as far as is practicable, from the beds and banks of all the streams flowing into these reservoirs, and also to make a few drains for the better collecting the various springs, and for leading off a little water here and there into ponds for the supply of cattle, so as to prevent their access where such would be injurious to the purity of the water; for this purpose allow five hundred (L.500) pounds.

Mode and cost
of conveying the
Pure water
from the Reser-
voir to a Basin
or Cesspool near
Listonshiells.

Supposing a reservoir for pure water to be formed above Easter Cairns, it will be advisable to carry the water from such reservoir to near Listonshiells by an aqueduct so constructed as to intercept the springs from the grounds above (as it passes along), without allowing any waste from its lower side. The distance is about 6,600 yards; and such aqueduct may be made, including every thing, at 7s. 6d. per lineal yard, which is two thousand four hundred and seventy-five (L.2,475) pounds.

Mode and cost
of conveyance
from Liston-
shiells to near
Craiglockhart

From Listonshiells to near Craiglockhart, the water should be conveyed in a close aqueduct, formed of stone, cemented

and puddled, as before stated. It is proposed to make the clear water-way of this aqueduct fifteen by eighteen inches; which, at the same proportional rate as the Greenock one, is thirteen shillings and ninepence; but (to err rather on the safe side) call it fifteen shillings the lineal yard. The length of this aqueduct, from its commencement near Listonshiells to its termination between Firhill and Craiglockhart, is twelve thousand eight hundred and seventy (12,870) yards; which, at fifteen shillings, is nine thousand six hundred and fifty-two pounds ten shillings (L.9652 : 10s.) For cesspools, sluices, air-cocks, &c., say three hundred (L.300) pounds; bridges, drains, culverts, &c., twelve hundred and seventy-four (L.1274) pounds; compensation for land and surface damage, eight hundred and thirty-five (L.835) pounds; incidents ten per cent., one thousand nine hundred and three pounds thirteen shillings (L.1093 : 13s.)—Making the whole cost of this compartment, Twenty thousand nine hundred and forty pounds three shillings (L.20,940 : 3s.)

It thus appears that a full supply of *pure water*, for a population of two hundred thousand inhabitants may be brought to within less than two and a half miles of Edinburgh for thirty-three thousand (L.33,000) pounds. And it is proper to observe, that the reservoirs and aqueducts have been purposely made large enough to afford this quantity, should it ever be required.

Total cost of conveying the Pure Water for 200,000 souls, to within two and a half miles of Edinburgh.

In the above estimate nothing has been put down as the price of springs.

With regard to the proprietors on the Water of Leith, it is understood, that they will readily concur, on receiving compensation in water; and if they were to receive it to the extent here proposed, there could be no doubt that the value of all property on the banks of this stream would be much enhanced both by the uniform, and greatly increased power of the mills, and by the removal of all danger to lands, buildings, or other property, from floods; for if the embank-

ments are constructed as they may and ought to be, it were just as reasonable to dread their breaking down, as that of Arthur's Seat or Pentland Hills.

The Reporter limited by his instructions from carrying his Estimate farther than Craiglockhart.

The Reporter being limited, by his instructions, to the collecting and carrying this water to within two or three miles of Edinburgh, cannot, of course, be prepared to state with accuracy what farther sum would be necessary, to carry it into and through the city and suburbs; but he has no doubt that, under skilful and judicious management, a supply fully equal in quantity and quality to that now distributed by the existing Company might be made forthcoming, for a sum greatly under the cost of the present water-works. And it is a mere popular prejudice, kept up, perhaps, by interested individuals, to suppose that no water but that *direct* from springs is fit for domestic purposes. In fact, no large and populous city, in this country at least, *has*, or *can have*, a *full* supply from such sources only; and if any such community are induced to believe that their *whole* supply is pure water direct from springs, they are imposed upon.

No springs sufficiently copious for the supply of large and populous cities.

Comparison between Spring Water and that of deep Lakes, &c.

Nothing certainly can be better than the water of *some* springs; but what, after all, is spring water? or what was it before it became spring water? Was it not all, at one time, common rain water, flowing on the surface of the earth, and mixing with or imbibing various ingredients or impurities as they might come in its way, till at length, after many windings and turnings, and slow and long-continued progress, through various strata, crevices, and natural cesspools, in the bowels of the earth, it at length reappeared at its surface as spring water? Now if water can be collected *at once* from the surface of the earth, and made to undergo such processes as will free it from the extraneous matters it may have thence imbibed or carried with it, what is then the difference between it and spring water? *Individuals*, indeed, *accustomed to certain mineral waters*, will prefer such; and they may, if they choose, have artificial filters to produce them; but

Comparison of the waters continued.

surely the object for the *community* at large is *pure water*. That this may be obtained otherwise than from springs, is not only possible, but constantly practised by nature herself, as must be evident to every one who observes her operations attentively. Only look at the fine quality of the water in Loch Lomond, Loch Leven, and other large bodies of water, where its great depth and constant motion have long destroyed (if ever they were there) every vestige of vegetation and vegetable matter. Now what the Reporter proposes, is merely to imitate nature in this respect.

The proposed supply will be partly from springs, but chiefly rain water, collected into a capacious and deep reservoir, where it may have ample *space* and *time* to deposit any extraneous matter which it may carry with it from the surface of the earth; and it has been already stated, *that all vegetable matter is to be removed from the site of this reservoir; and that moss water, or water holding such substance in solution, is not to be permitted to enter it.* This, the reporter knows, from long experience, to be quite practicable; and also that filters *may* be made, capable of removing matter *held in solution by the water*, as well as that merely *suspended* in it; but the first will be found very expensive. Such filters might be very conveniently placed at the lower end of the conduit; but the reporter is of opinion, that if this plan is properly carried into effect otherwise, they will not be necessary.

The proposed supply partly from Springs and partly from Surface-water, collected into a deep Reservoir, &c.

The great object is, to collect the water when pure, and particularly when free of all substances held in solution; and during the year, a much greater quantity of such water may be thus collected, than can be required for the whole supply of the city of Edinburgh. All that is wanted, therefore, is merely to collect this pure water, at proper times, into a reservoir sufficiently capacious, and properly constructed for that purpose.

Quality of the proposed Supply continued.

But it is of great importance to the purity of the water, that the reservoir containing it should be *capacious*,—in particular, it ought to be *very deep*, so as to give ample time and

Quality of the
proposed Sup-
ply continued.

space for the deposit of sediment,—and that the water, by being drawn off at a great depth from the surface, may be nearly of the same temperature in summer and in winter. Moss, and all other matters soluble in water, should be carefully removed from the site or bed of this reservoir; and a part of its bottom, near the outlet, should be at least eight or ten feet deeper than that outlet, so as to prevent the possibility of any mud or sediment being carried along with the water into the aqueduct.

Quality of the
proposed Sup-
ply of Water
continued.

It may be said, that when nearly all the water in the reservoir is drawn off, it must be taken from near the surface, and will, of consequence, be warm. But the reservoir should be so large as *never* to be drawn off so low as the level of the outlet; and if at the end of a *very long* drought it should be nearly so, yet the aqueducts and pipes being all laid *very deep in the earth*—and there being, besides, several *deep* cesspools into which the water falls afterwards—and also a *very deep* basin, where the stone aqueduct ends, the water would still be cool before it reached the city. Indeed, the basin at the lower end of the stone aqueduct, being *very large*, and particularly *very deep*, will do much of itself towards cooling the water on such occasions. But however cool the water may be when brought into the city, or however cool it may be even in the pipes in the streets, yet in warm weather (if not generally) the water *within* the houses will be warm; and, therefore, when cool water for the table is wanted, this warm water should first be drawn off for common purposes. If these and all other necessary precautions are attended to, the water may be had nearly equally cool in summer and in winter. But when the pipes in the streets happen to be laid *very near the surface*, the water in the pipes there is often so much *heated* during warm weather, as to become nearly *putrid*, and altogether unfit to be used. This is the case in several towns, and particularly so in Glasgow.

How to have
Cool Water for
the Table.

Should any be inclined to doubt the purity of water so

procured, the Reporter would beg to direct the attention of such to all large collections of water ; particularly to all *deep* lakes, free of moss or other vegetable matter : it being distinctly kept in view, that all such substances are to be carefully removed from the site of *this reservoir, and from the beds of all the streams conveying the water into it* ; and that no moss water, or impure water of any kind, is ever to be permitted to enter the reservoir.

Quality of
Water con-
tinued.

The Reporter has already stated, that under skilful and judicious management, the amount of the estimate here given is fully equal to its object. But if the *jobbing* and *bungling* shall not, upon the whole, exceed ten per cent. on the *necessary* expenditure, then he is confident that this estimate will cover all the outlay ; but he frankly admits that to make an estimate equal to the expense under *any* management, is above his capacity. He is of opinion that this estimate is equal to the accomplishment of all it proposes under proper management.

It will be observed that the reservoir proposed by Mr. Stevenson, (in his report dated 21st November, 1825,) is to contain forty-four millions (44,000,000) cubic feet of water ; and that he estimates the cost of this reservoir, collecting the water, and conveying it to the regulating cistern near Firhill, in a cast-iron pipe, (partly of 13 and partly of 14 inches bore,) at something above sixty-five thousand (L.65,000) pounds.

Comparison
between Mr.
Stevenson's
plan and Mr.
Thom's.

Cost by Mr.
Stevenson's
plan.

The reservoirs proposed by the Reporter will contain about one hundred millions (100,000,000) cubic feet of water ; the stone conduit proposed by him, to convey the water to the said cistern near Firhill, is fifteen by eighteen inches clear, (nearly double the water-way of the above cast-iron pipes) ; and the expense of this conduit, of the reservoirs, collecting the water, and conveying it to the cistern near Firhill, in the immediate vicinity of Edinburgh, he estimates at a trifle above thirty-three thousand (L.33,000) pounds.

Cost by Mr.
Thom's plan.

In the present state of intelligence, the Reporter considers it quite unnecessary for him to say one word on the beneficial effects which such a rival establishment must confer on the community, by the consequent and salutary competition in supplying them with one of the first necessities of life.

(Signed)

ROBT. THOM.

(TRANSLATION.)

Paris, 20th January, 1837.

Department of
Maine & Loire. }
Mayor of the
City of Angers. }

The Mayor of the City of Angers, to Mr.
Thom, Civil Engineer at Greenock.

SIR,

Hydraulics, that important part of mechanics, owes much to your immense labours; what you have published on this interesting subject is justly appreciated in France, and by the learned of all nations. Your name, among us, is honourably associated with those of *Mariotte*, *Prony*, *Fourier*, and *Poisson*. When, therefore, the question is, to supply a numerous population with pure water, it is our duty most earnestly to beg of you, the result of your experience, and of your skill. It is on this point, Sir, that I entreat you to have the goodness to give me information. I hope that you will not refuse to send me all the documents which I require, in order to come to a final determination. The true *savant* belongs to every country; to be useful to mankind is his sweetest enjoyment, and the gratitude which he experiences for the services he has rendered, often gives him more pleasure than all the honorary titles which could be conferred upon him.

Our city, Angers, is the capital of an ancient province, Anjou, of which the name is, doubtless, not unknown to you; its population is about 35 or 40 thousand inhabitants. Angers possesses no public fountains; the water of the wells is generally unfit to drink; and we have intended these many years to construct public fountains. We are now seriously engaged in this project, and the municipal administration has

made, on this occasion, an appeal to all who could give them information on this useful undertaking.

A river called the *Maine* runs through the city, and divides it into two parts, which are connected by bridges. The bottom of this river is clayey, often muddy, and of variable depth. Chemical analysis, as well as medical observations, have demonstrated that its water is salubrious, and fit for drinking. This water contains in solution, when the river is low only, a very small quantity of vegetable organic matter, of which the proportion is variable, and depends on the plants which grow on the banks of the *Maine*. The taste and the colour of the water are then slightly affected; but, excepting this, its purity is not otherwise injured by them, though we feel a particular taste when we drink it fresh drawn from the river. When allowed to settle for 24 or 36 hours, at a low temperature, this particular taste is partly removed. This is especially the case after filtration, which removes it so much that it is then difficult to distinguish between it and other waters which are equally filtered, and which have no perceptible taste. Thus, when filtered, the water of the *Maine* is perfectly limpid, entirely transparent, and its softness, at the same temperature, is comparable to that of the rivers whose waters are the most celebrated. It is well adapted for culinary purposes; soap is easily dissolved in it, the solution being only slightly disturbed, without being curdled. The evaporation of a litre of it leaves for a residuum a yellowish mass, weighing 157 milligrammes, which, when submitted to analysis, is found to be formed of

	Gr.
Subcarbonate of lime, . . .	0·110
Subcarbonate of magnesia, . . .	0·006
Hydro-chlorate of soda, . . .	0·022
Hydro-chlorate of lime and magnesia,	0·006
Organic matter, and loss, . . .	0·013
<hr/>	
Total, . . .	0·157

Can the principles of filtration, which you have so ingeniously developed and put in practice for the town of Greenock, and of which you have made several times a happy application in other places, when you were employed to filter large masses of water, be employed with advantage in filtering the water of our river? The answer to this question cannot be doubtful, if we read again with care the letter you wrote to Sir Michael Shaw Stewart, dated 20th March, 1829, a letter of which M. Mallet has given a translation, almost literal, in the first volume of the "*Annales des Ponts et Chaussées*," for the year 1831, page 222. The object of this letter is to demonstrate, in a clear manner, the possibility of supplying large towns with filtered water, by constructing a filter, of which you have given a very clear and minute description. The most of the filters which we have hitherto employed have not acted so well as we could wish, and others are either too expensive in their construction, or require every year too heavy charges for keeping them in repair. Most of us are therefore of opinion that the filter which you have invented, and applied with such success at Greenock, would be the most answerable for our purpose; whilst others still entertain a doubt whether even these filters could be applied, without great difficulty and expense, to the purification of waters raised, like those of the Maine, by the aid of machinery.

Would you therefore, Sir, have the extreme kindness, after the notes I have sent you, to answer the following questions, which I have the honour to propose to you?—

1st. How long have the filters which you constructed at Greenock been in operation? Do they always act well? Are they subject to frequent and costly repairs?

2d. Could we, with the hope of complete success, apply them to the waters of the Maine? The quantity to be filtered in 24 hours being estimated at one and a half or two million litres? What modifications or changes would your filters then require—elevation of water, &c. &c.?

3d. Could you give me an idea of the expense of the erection and annual maintenance of these filters? It would be very useful for me to be informed on this question, which is of the greatest importance to us—for without it, we cannot come to any decision.

4th. In your opinion, ought we to count as much upon the results obtained by the aid of artificial filtration, as on those obtained by natural filtration? I beg of you to resolve this question, not on account of the waters of the Maine, which cannot be purified naturally, the nature of the ground completely preventing it, but because about a league from our town, there is the fine river of the Loire, whose water, according to some, could be filtered through the sand which is on the banks of the river. Would this filtration offer chances in its favour, and could we reckon for a long time on such a filter? The alluvial bank, in which we wish to make the filtration of the water of the Loire, is formed of fine sand. Do you think that this natural filter would operate for many years, and that it would be able to furnish *regularly* and without speedy *interruption*, the quantity of water, which we wish to take from the Loire? You will easily perceive, Sir, that we have in this case compared the nature of the banks of the Loire with those of the waters of the Garonne for the fountains of Toulouse. You know, in fact, that M. D'Ambuisson has made, in the alluvial bank near that river, three natural filters, which although made in the *same* ground, have nevertheless given (defferent) *different* results. Is the comparison which we have made in this instance, correct? Your numerous and laborious researches on this interesting subject will be of great use to us, and I beg again the result of your long experience. You have examined the different modes of filtering water with so much zeal and unremitting perseverance, that your opinion alone ought, so to speak, to make the law; and there is no person abler than you, to give place to in such a matter.

Would you, Sir, send me your reply as soon as you can? I shall wait for it with great impatience. In two months we must come to a final resolution.

Receive, Sir, before-hand, the expression of my sincere acknowledgments and most grateful thanks.

Accept, Sir, the assurance of my highest respects.

(Signed,) The Mayor of Angers, Member of the
Chamber of Deputies,

AUGUSTIN GIRAUX,
Rue neuve des Mathurins 56.

